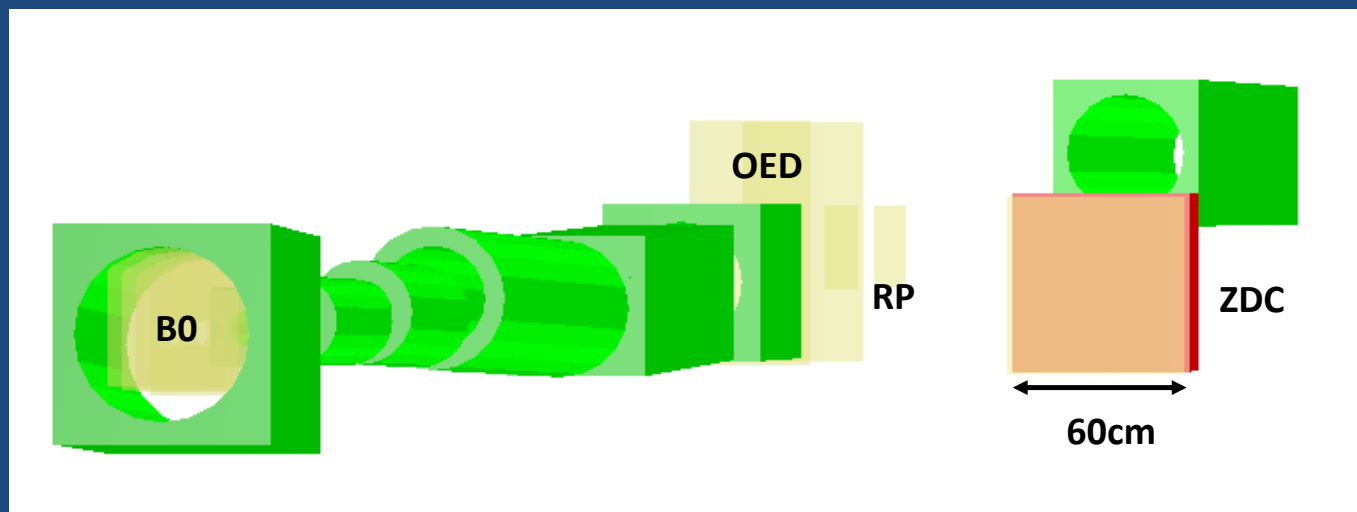


Developing a high resolution ZDC for EIC

- Groups from the US and Japan are planning to design a ZDC for the EIC.
- For 2021 we will focus on simulations.
- The project leverages ongoing work on several fronts but has no critical external or internal dependencies in 2021.



Yuji Goto & Michael Murray for
ZdEiC team 27th July 2020

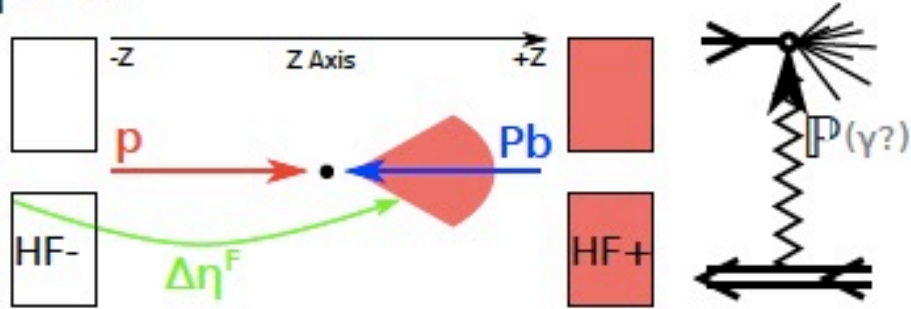
Physics drives detector requirements

Detector R&D	Physics	Performance requirements	Resource requested	Support & collaboration
Soft photon detection	e+A nuclear breakup veto	$E_\gamma \leq 300$ MeV	detector simulation	This proposal Calorimeter consortium
		acceptance	acceptance simulation	This proposal BeAGLE group
		detector technology	detector R&D	N/A in FY21
EM + hadron calorimeter	e+A collision geometry	neutron multiplicity	high resolution not necessary	BeAGLE group
	spectator tagging	energy & position resolution	detector simulation	This proposal
	meson structure	neutron & Λ acceptance	detector simulation	This proposal Meson structure WG
		detector technology	FoCal R&D	RIKEN
			LHC-ZDC R&D	Kansas Univ.
		calibration scheme	design & simulation	This proposal
			system test	N/A in FY21
Radiation hardness		radiation dose	simulation study	This proposal Kobe Univ.
		detector technology	radiation test	This proposal Calorimeter consortium

Need excellent photon & neutron energy resolution in energy and position.

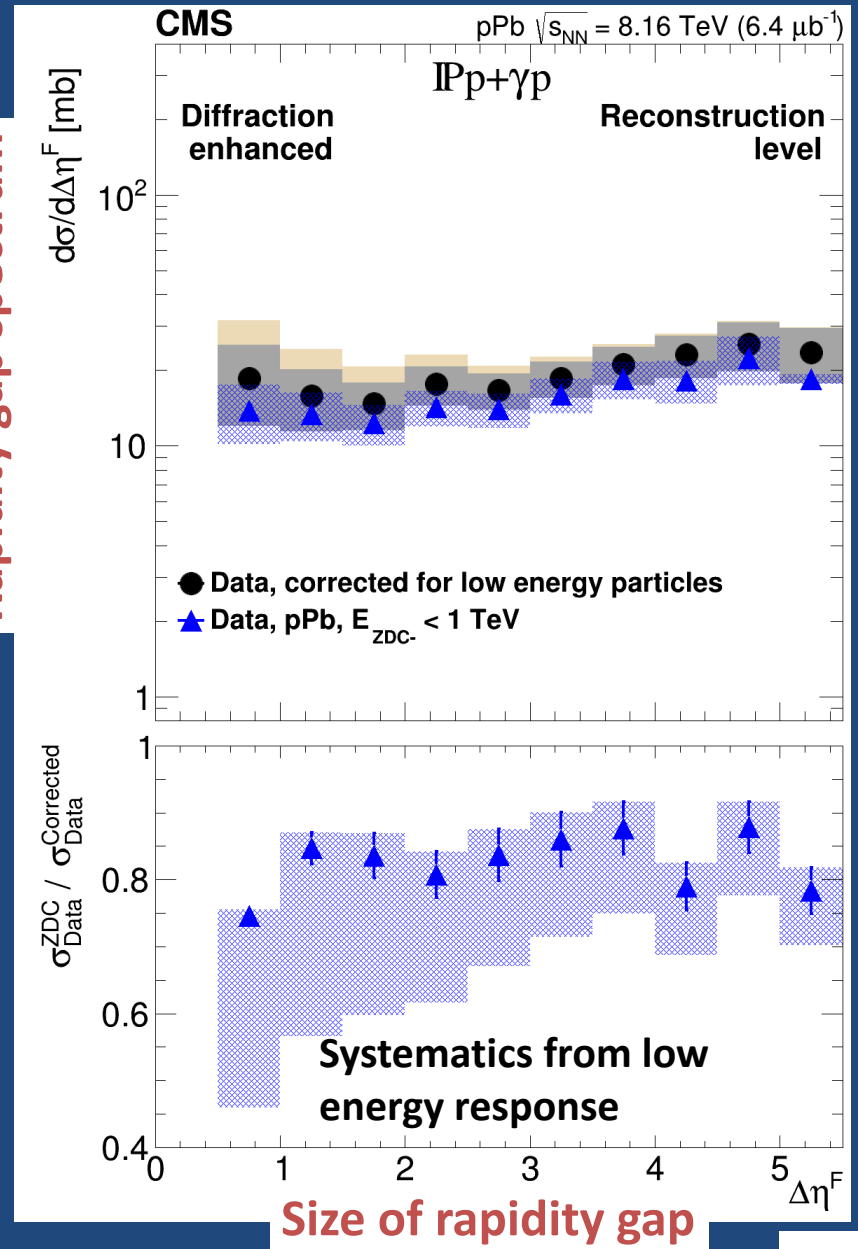
CMS vetoing nuclear breakup in pPb

pPb



For pPb we study events in which the proton is hit by a photon or pomeron & there is a large rapidity gap. Vetoing on the ZDC eliminates events with very soft particles at forward eta.

Rapidity gap spectrum

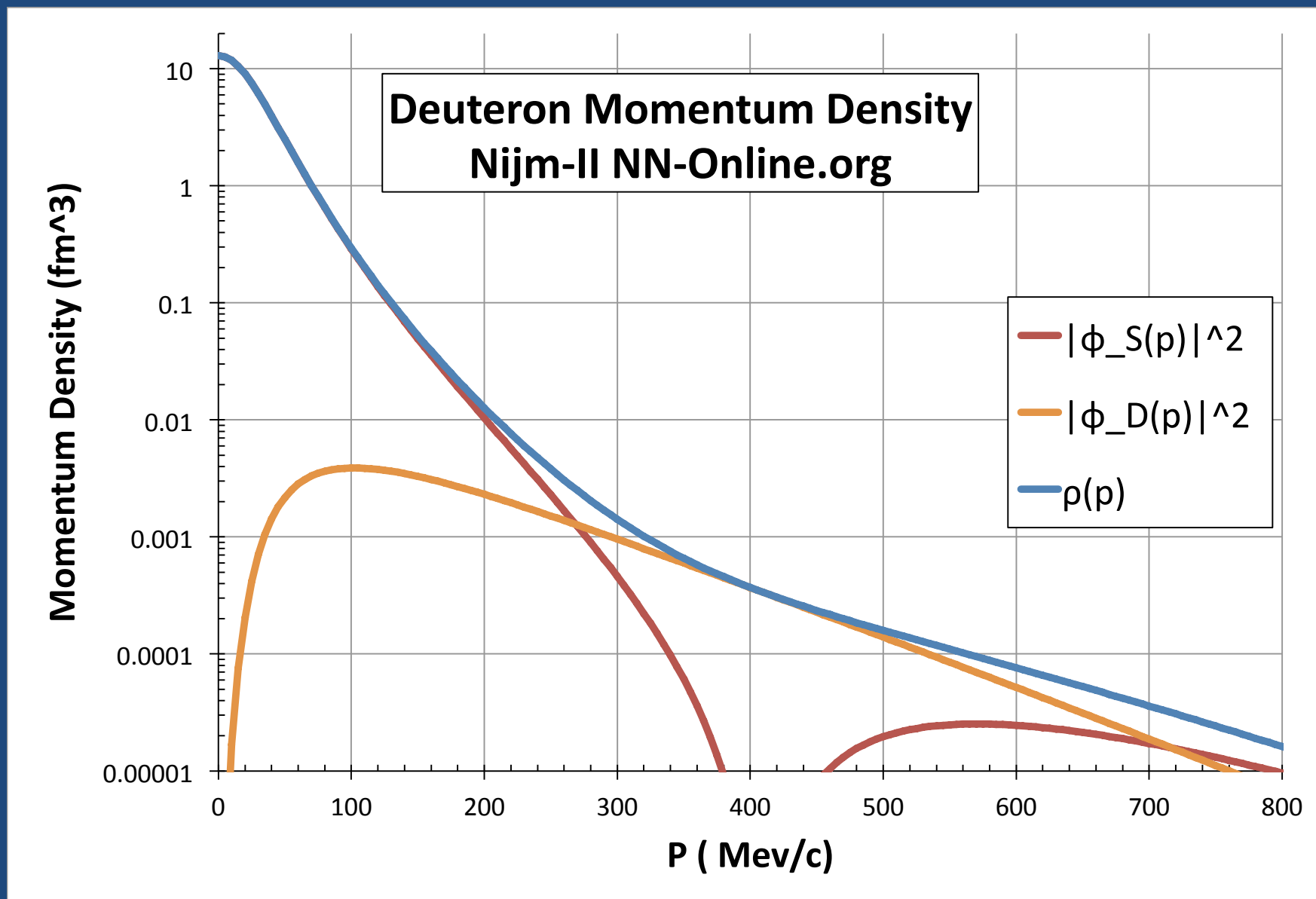


CMS PAS HIN-18-019

ZdEiC

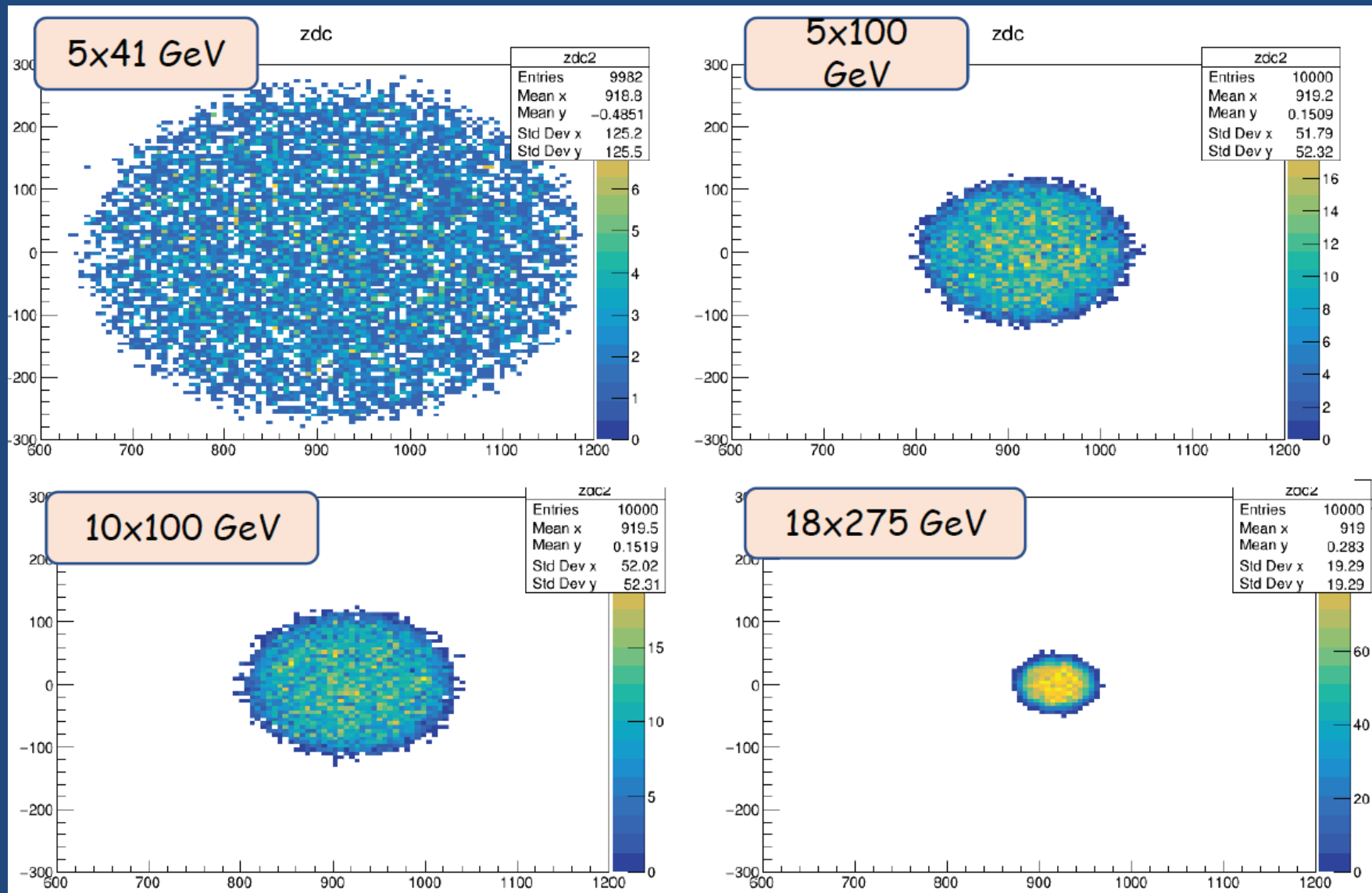
The deuteron momentum distribution

Need to accurately measure neutrons with p_T in the 100 MeV range



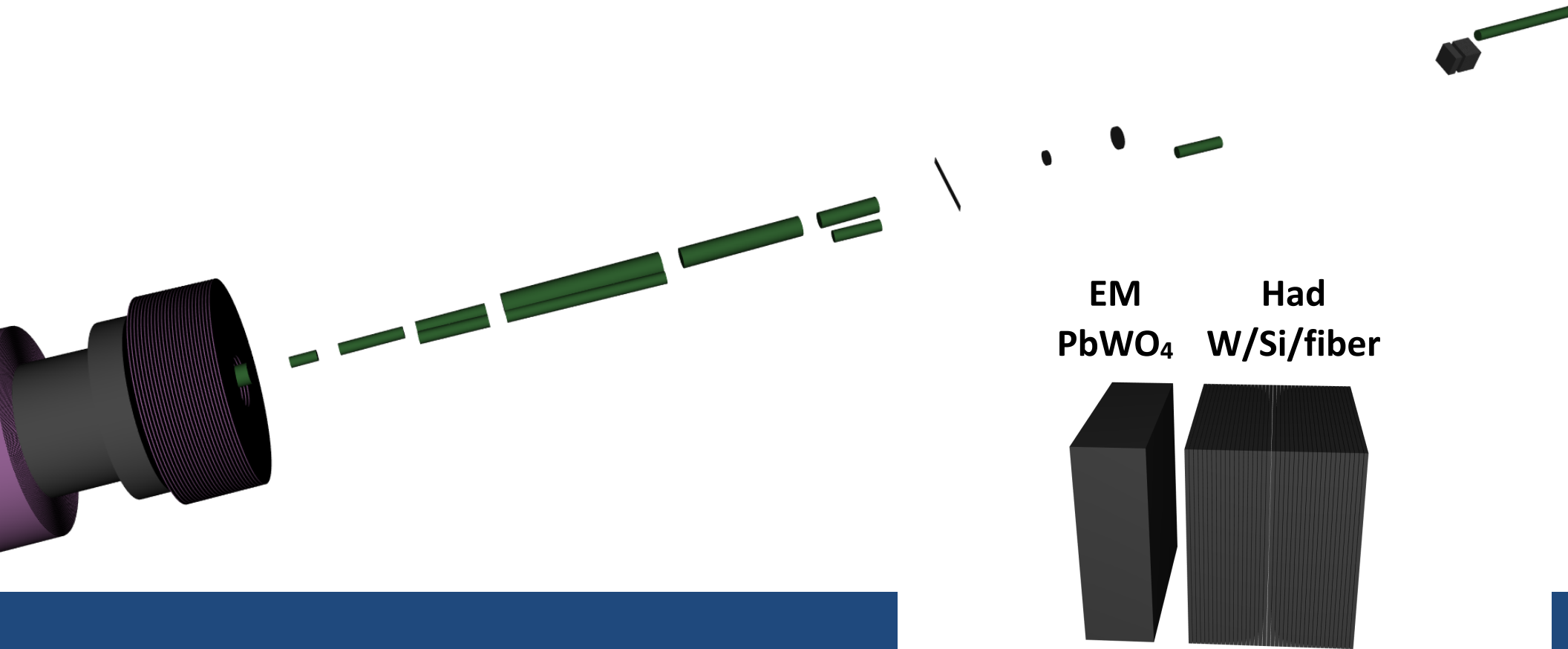
Size of 60cm x 60cm should be sufficient

Y distance from beam (mm)

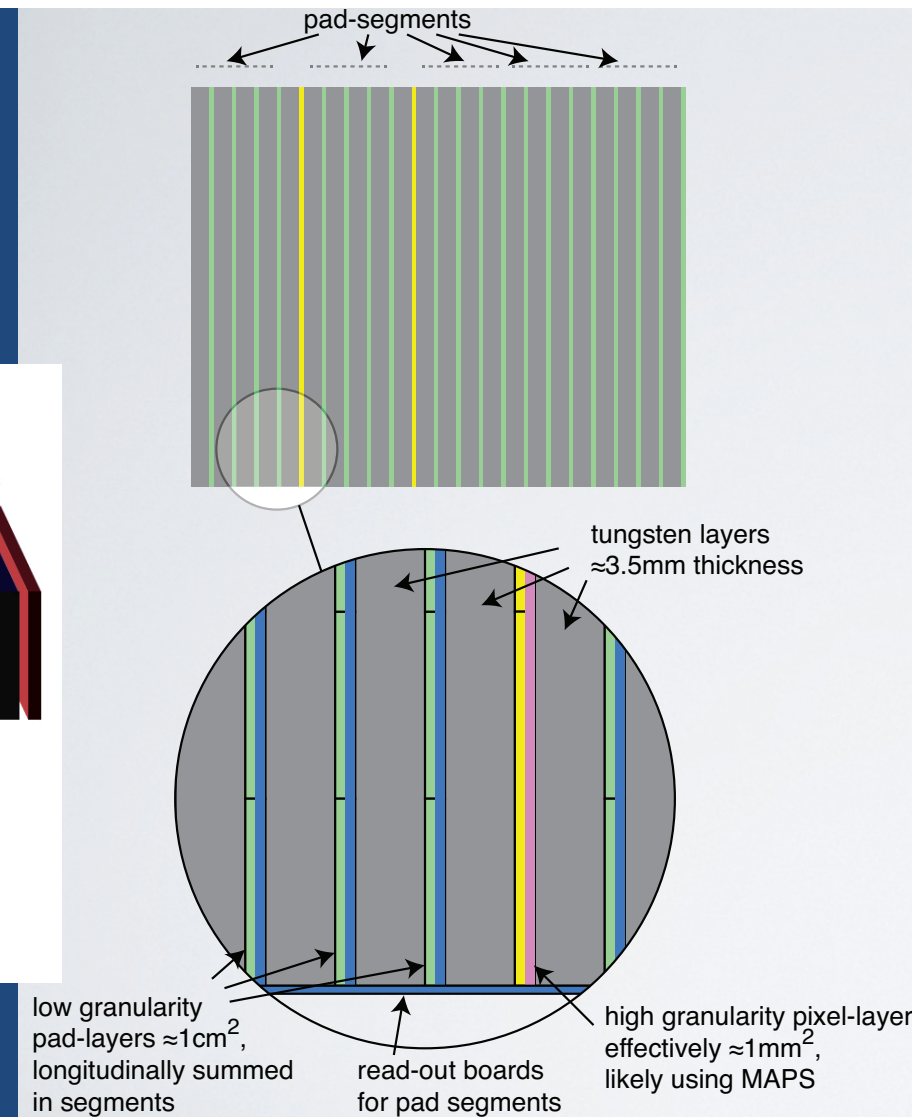
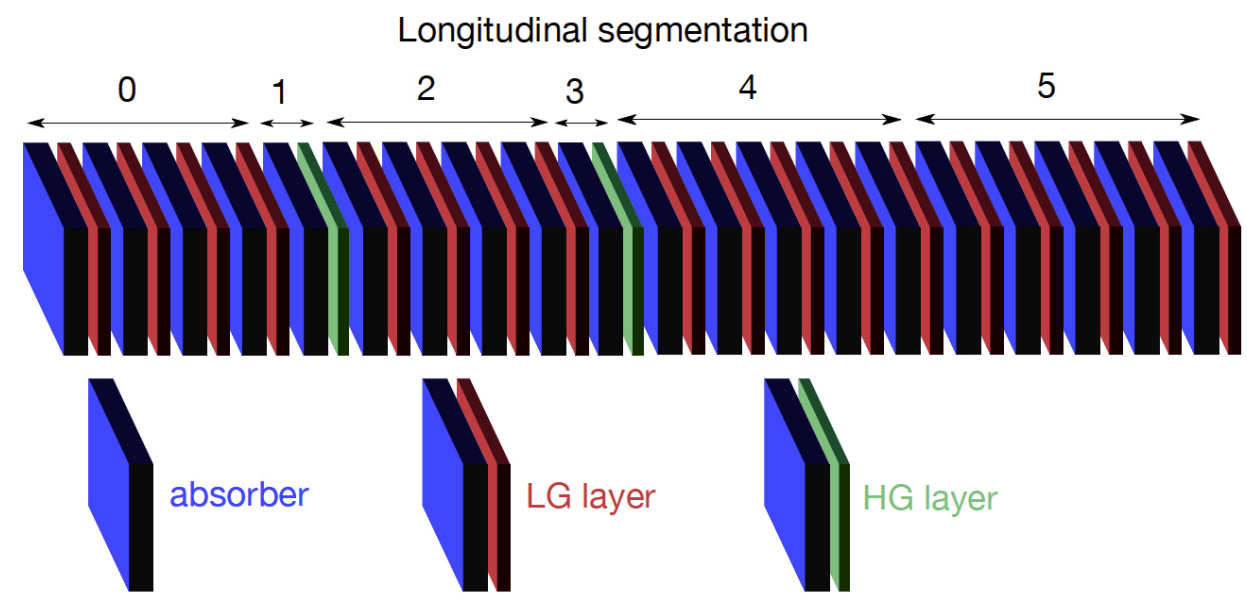


X distance from beam (mm)

First implementation in EIC framework

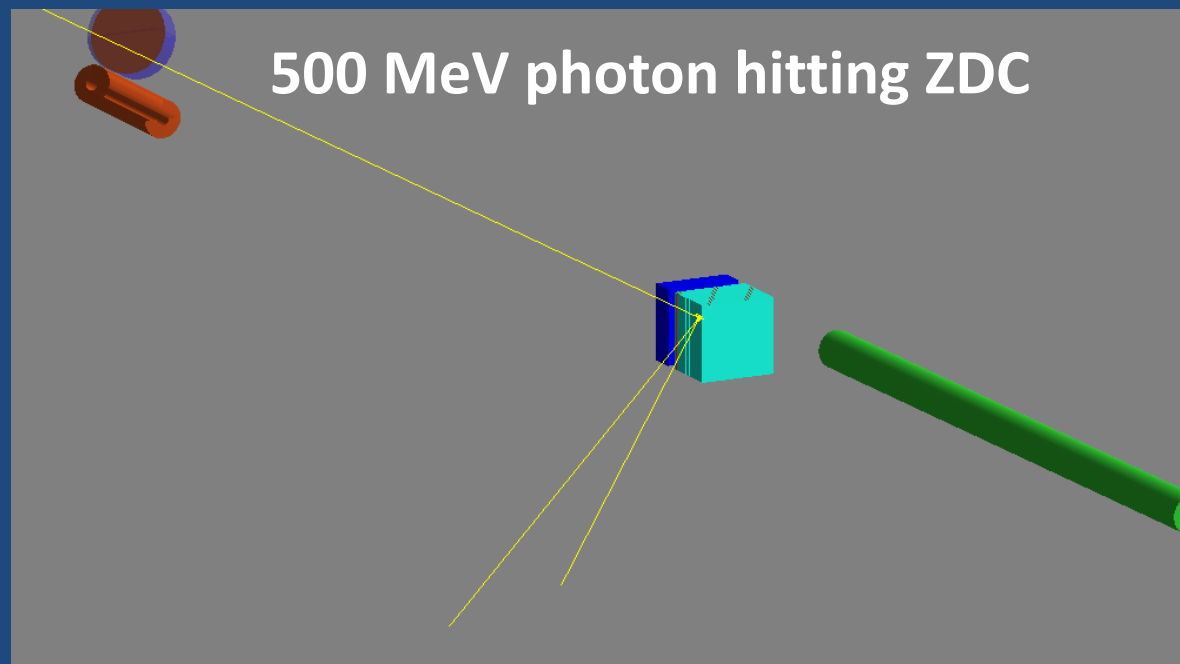
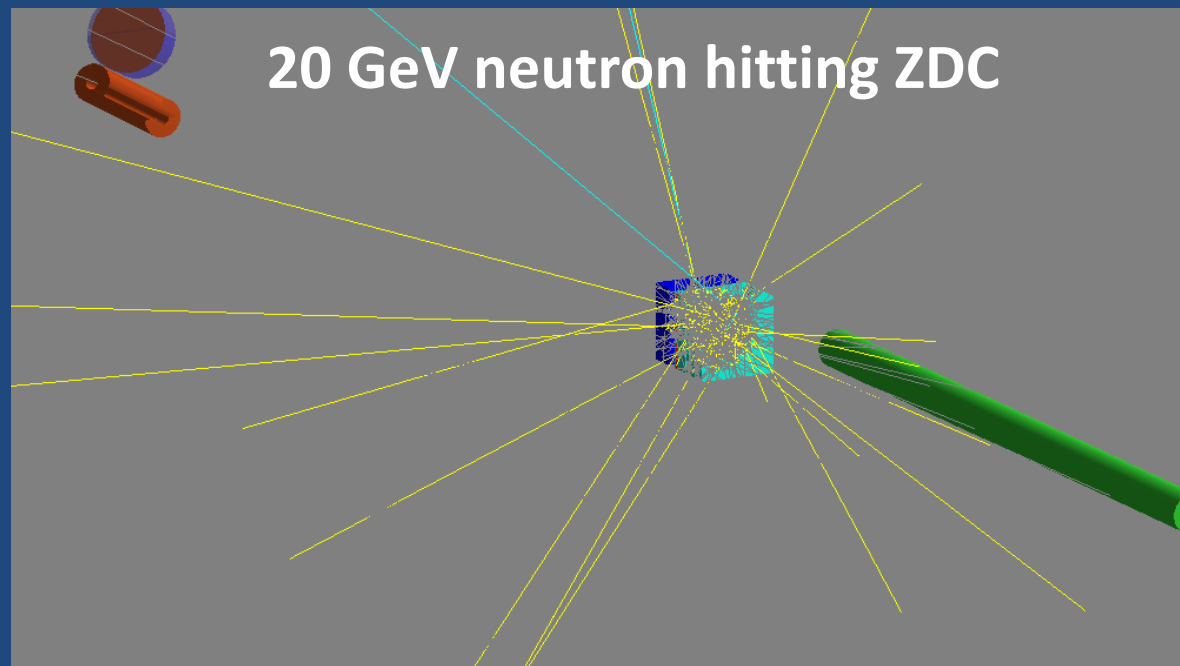


Focal W/si calorimeter

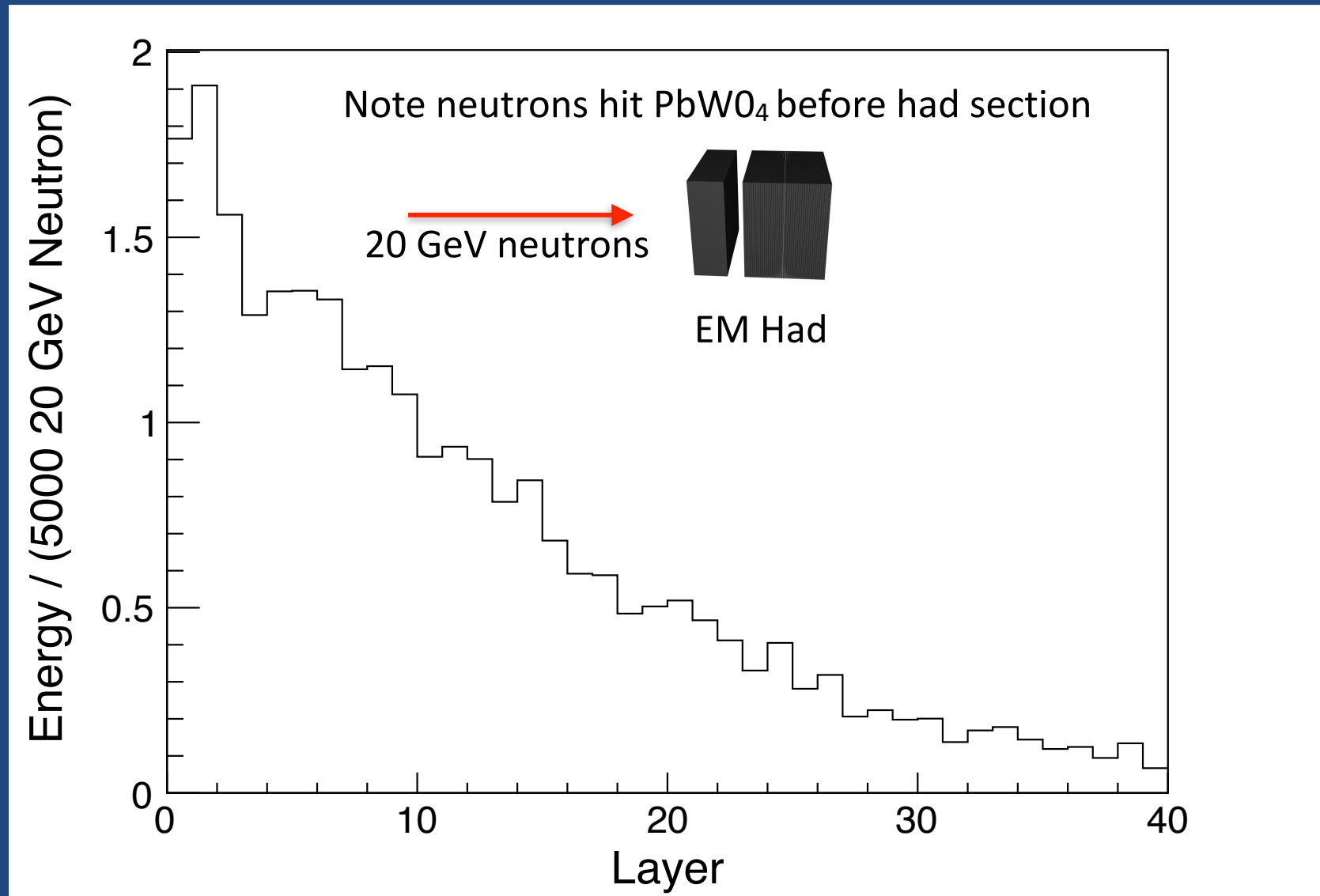


High granularity allows reconstruction of individual showers for precise position resolution and timing. We will add PbWO₄ crystals in front for low energy photons and may also add silica fibers to tag high energy core of the shower.

Event Displays



Response of Had section to 20 GeV neutrons



Schedule & deliverables for 2021

Period	Task	Group
10/2020 - 12/2020	Integration of simulation tools	KU
1/2021 - 3/2021	Test against physics requirements	KU/SBU
	Acceptance, σ_E , σ_{pT}	KU
3/2021 - 5/2021	Comparison of different crystals	KU
3/2021 - 9/2021	Optimize neutron reconstruction	KU
6/2021 - 9/2021	Background studies	ODU
10/2020 - 12/2020	Radiation dose estimate	Japan
1/2021 - 7/2021	Test of Focal prototype	Japan
1/2021 - 7/2021	Test of CMS prototype	KU
7/2021 - 9/2021	Prepare publication	All

Budget for 2021

Item	Institute	Cost
Postdoc 1/3 FTE	Kansas	\$ 40K
Travel to BNL 3 people	Riken	\$ 10k
US Travel	Old Dominion	\$ 2k
Grad student summer	Old Dominion	\$ 10.5k
Total		\$ 62.5k

Committee report on preliminary proposal

The committee very much welcomes submission of the full proposal. The physics clearly motivates the research proposed. The project has a broad scope and a relatively small budget and seems to depend on efforts that are outside of the scope of this proposal (see Table 1 in the proposal). It would be appreciated if these external dependencies can be addressed during the meeting and what the internal dependencies are. For example, how does the FoCal R&D at RIKEN depend on elements of this proposal and vice versa.

The project has 4 external dependencies

- BeAGLE for simulation of nuclear breakup
- Yellow report group on meson structure for forward neutron, π^0 production
- FoCal R&D for ALICE
- Rad hard fiber technology from ATLAS & CMS.

Dependence on BeAGLE for breakup

- The ZDC can veto nuclear breakup, see CMS-PAS-HIN-18-019 on diffraction in pPb.
- To estimate our efficiency we need to know the spectra of photons & neutrons from breakup
 - For example it may be considerably easier to tag Pb breakup than that of Au
- We can use current estimates to start but it would be very helpful to refine the breakup sequence within BeAGLE.
- For a ZDC at a second IR with complimentary acceptance it would also be important to have the most realistic physics possible in our simulations.

Dependence on meson structure studies

- ZDCs help measure electron scattering off the π cloud around the proton by reconstruction forward neutrons & π^0 .
- This process is being studied by the Diffraction & Tagging YR group, see <https://indico.bnl.gov/event/7352/timetable/>
- CFNS workshop on π , k structure functions
- There is not yet a full specification of detector requirements but we can already start to estimate our ability to reconstruct π^0 .

Dependence on FoCal R&D

- The FoCal project is vital to ALICE upgrade, see <https://cds.cern.ch/record/2696471> and is already well advanced.
- Several Japanese groups are funded for this.
- We have leveraged this work for our initial idealized design
- Moving to a more realistic design with dead areas for readout & services we will benefit from their experience.
- Focal groups already planning on radiation tests.

Dependence on ATLAS/CMS ZDC

- We may incorporate rad hard fused silica developed for LHC forward detectors.
- These fibers are already tested at higher doses than we expect to see at EIC.
- LHC group also has done significant work on calibrating Fluka dose simulations and we can benefit from this.
- LHC group planning new test beam campaign when Covid permits. This will help calibrate simulations.

External Dependencies not critical for 2021

- Although the ZdEiC benefits from external input from several sources none of these can derail the goals we have set for 2021.

Internal Dependencies

- For 2021 we are proposing 1/3 of FTE to work on simulations.
- KU nuclear group as 3 postdocs, 7 students and 4 faculty so this level of effort should work
- ODU and SBU groups are very knowledgeable of physics and backgrounds
- Japanese groups are well funded for FoCal and have access to radiation facilities & test beams.
- Covid may delay some non-simulation activities

Summary

- ZdEiC group has sufficient depth & expertise to design a ZDC that meets physics specifications
- The project leverages ongoing work by BeAGLE, EIC tagging group, FoCal and LHC ZDC but has no critical external dependencies in 2021.
- The group is large enough to execute the project without the need to hire new personnel.
- Covid may slow some aspects of the project but we are confident that simulations will succeed.

Backup